

Executive Summary

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Observing the United States' Homelessness Crisis through Mathematical Methods

Mufaro Machaya, Nam Le, Ben Stilwell
Cy-Fair Senior High School
Cypress, Texas

March 3, 2024

Contents

1	Introduction	4
2	It was the Best of Times	5
2.1	Restatement of the Problem	5
2.2	Assumptions and Justifications	5
2.3	Model Development	5
2.4	Results	8
2.5	Reflecting on the Model	8
3	It was the Worst of Times	10
3.1	Restatement of the Problem	10
3.2	Assumptions and Justifications	10
3.3	Model Development	10
3.4	Results	13
3.4.1	Albuquerque, New Mexico	13
3.4.2	Seattle, Washington	13
3.5	Reflecting on the Model	13
4	Rising from this Abyss	15
4.1	Restatement of the Problem	15
4.2	Assumptions and Justifications	15
4.3	Model Development	15
4.4	Results	15
4.5	Reflecting on the Model	15

1 Introduction

Understanding the housing shortage has become more important than ever, as rates of homelessness have reached unprecedented and potentially dire level[1]. Moving into the future, it is undeniably critical for promoting the general welfare of United States populations to best understand housing for influencing public policy across major cities in the United States. Thus, we have prepared the following mathematical models to best understand such a trend.

2 It was the Best of Times

2.1 Restatement of the Problem

The first problem asks us to develop a mathematical model to predict changes to the housing supply over the next 50 years in two cities of our choosing: Seattle, Washington; and Albuquerque, New Mexico.

2.2 Assumptions and Justifications

There will be no immense, drastic, and long-term permanent changes to housing production possibility within the next fifty years.

Justification: Events that will drastically change the ability to produce housing, such as immense wars or widespread natural disasters, are neigh-impossible to detect accurately with a simple mathematical model. The only events that can be accurately tracked through mathematical means over short periods of time are cyclical events, like economic recessions or inflation.

Occupied housing will not be considered part of the available total housing supply.

Justification: In regards to fixing the homelessness crisis, housing that can be considered available for allocation to unhoused people inherently must be unoccupied by others.

Differences in median housing costs and median income per capita across regions in both Albuquerque and Seattle will not be considered in determining housing availability.

Justification: These factors hold a strong correlation with housing unavailability, yet we assume them to have no causal relationship.

2.3 Model Development

For our housing availability model, we choose to use a simple vector machine that regresses historical housing availability data for both Albuquerque and Seat-

tle, and from there, we cross-reference this data with historical economic trends across the United States to best model housing availability over time given cyclical economic trends.

To begin, we trained the model on the following datasets for housing availability in Albuquerque and Seattle and the national GDP of the United States.

Year	Total housing units	Occupied units	Vacant units
2010	234,891	217,256	17,635
2011	237,735	220,060	17,675
2012	239,718	222,584	17,134
2013	240,277	222,491	17,786
2014	240,961	222,868	18,093
2015	241,326	222,098	19,228
2016	242,070	221,320	20,750
2017	243,402	221,119	22,283
2018	244,382	222,748	21,634
2019	245,476	224,166	21,310
2020	247,926	229,701	18,225
2021	252,924	236,191	16,733
2022	255,178	239,800	15,378

Table 1: Housing Statistics in Albuquerque, New Mexico [2].

Year	Total housing units	Occupied units	Vacant units
2010	302,465	280,453	22,012
2011	304,164	282,480	21,684
2012	306,694	285,476	21,218
2013	309,205	288,439	20,766
2014	311,286	290,822	20,464
2015	315,950	296,633	19,317
2016	322,795	304,157	18,638
2017	334,739	314,850	19,889
2018	344,503	323,446	21,057
2019	354,475	331,836	22,639
2020	367,337	344,629	22,708
2021	362,809	337,361	25,448
2022	372,436	345,246	27,190

Table 2: Housing Statistics in Seattle, Washington [3].

Due to the limited size of the dataset, we chose to use a C value for our SVM closer to 1.0 to prevent overfitting or underfitting of the data.

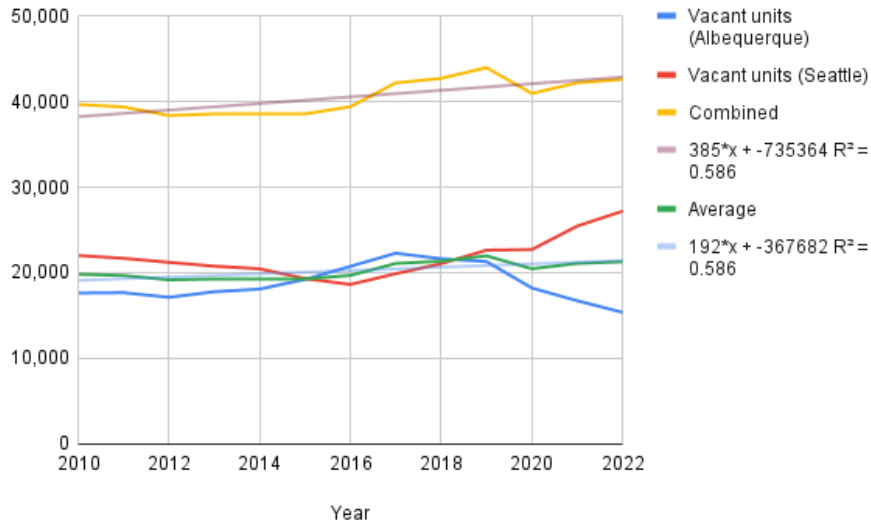


Figure 1: The number of vacancies in Albuquerque and Seattle from 2010 to 2022 [2, 3].

Let $H(x)$ equal the number of available houses for a given year, where x is the current year (absolute from year 0, such as 2024). Simple regression on this dataset results in a total trendline of

$$H_{\text{TOTAL}}(x) = 385x - 735,364$$

where $R^2_{\text{TOTAL}} = 0.586$, and an average trendline of

$$H_{\text{AVG}}(x) = 192x - 367,682$$

where $R^2_{\text{AVG}} = 0.586$.

A coefficient of determination of 0.586 is undeniably subpar due to the immense indifficulty in representing vast differences across the trends with linear functions.

2.4 Results

With this model, we can predict the following housing statistics for 2034 (10 years in the future), 2044 (20 years in the future), and 2074 (50 years in the future):

Year	Years from 2024	Total Available Homes	Average Available Homes in Each City	Change from 2024
2024	0	43,876	20,926	0
2034	10	47,726	22,846	1,920
2044	20	51,576	24,766	1,920
2074	50	63,126	30,526	1,920

2.5 Reflecting on the Model

Overall, our model proves generally weak at predicting immense, unforeseen changes to the economic situation of both cities such as the advent of war, the outbreak of a major epidemic/pandemic, or a large-scale natural disaster. This model is best for serving as a general, aggregate predictor of housing availability based on cyclical economic trends. Our coefficient of determination R^2 is certainly low, indicating a lack of accuracy, but this is certainly due to the difficulty of modeling previously-mentioned large-scale events with a linear model.

Altogether, we can conclude that this model's impact serves best as a general guideline for understanding realistic public policy because it is solely based largely on aggregate, cyclical economic factors that can be reasonably relied upon to occur continuously.

3 It was the Worst of Times

3.1 Restatement of the Problem

The first problem asks us to develop a mathematical model to predict changes to the homeless population over the next 50 years in two cities of our choosing: Seattle, Washington; and Albuquerque, New Mexico.

3.2 Assumptions and Justifications

Public policy regarding homelessness will stay roughly the same throughout the next fifty years.

Justification: We assume that there will be no significant changes to government policy that would severely change the homeless population, as these immense changes to public policy require immense predictions of political trends beyond the scope of this study.

3.3 Model Development

For our model, we used yet another linear support vector machine for simple linear regression at $C = 1.0$ as trained on the following data sets:

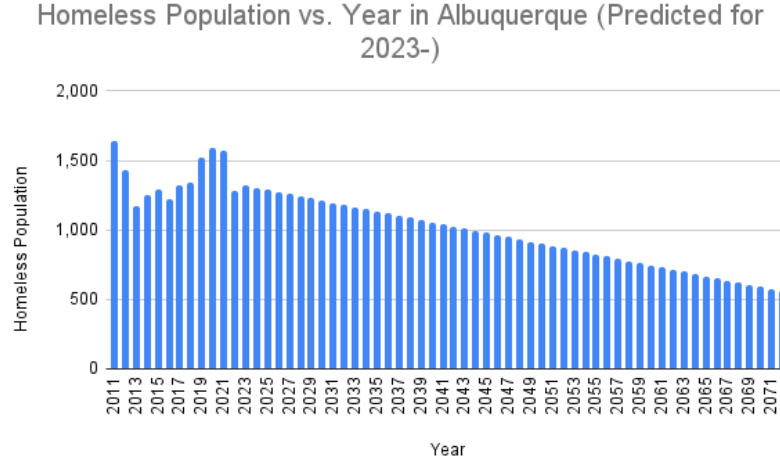


Figure 2: Total Homeless by Year in Albuquerque, New Mexico

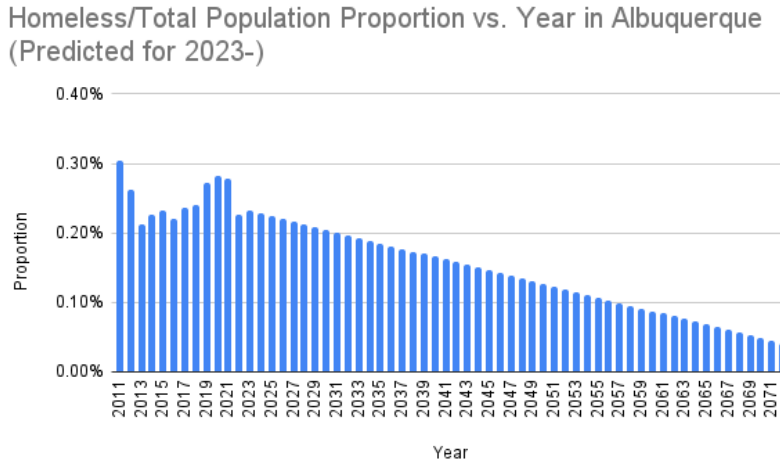


Figure 3: Percentage of the Population that is Homeless in Albuquerque, New Mexico

Therefore, for Albuquerque, let $A_T(x)$ be total number of homeless people in Albuquerque, where x is the current year (which is absolute from 0, such as 2024).

$$A_T(x) = 32,757.7 - 15.54(x)$$

Additionally, let $A_{\%}(x)$ be the percentage of Albuquerque's population that is homeless, where x is the current year (which is absolute from 0, such as 2024).

$$A_{\%}(x) = .08124 - 3.9(x) \times 10^{-5}$$

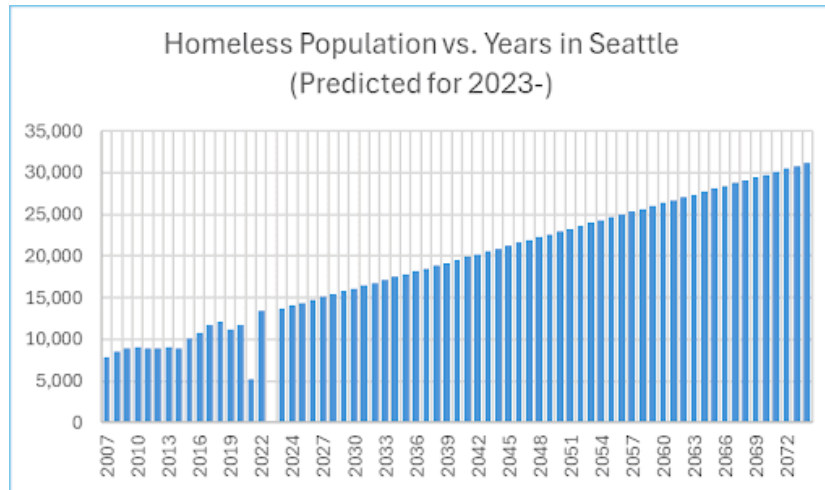


Figure 4: Total Homeless by Year in Seattle, Washington

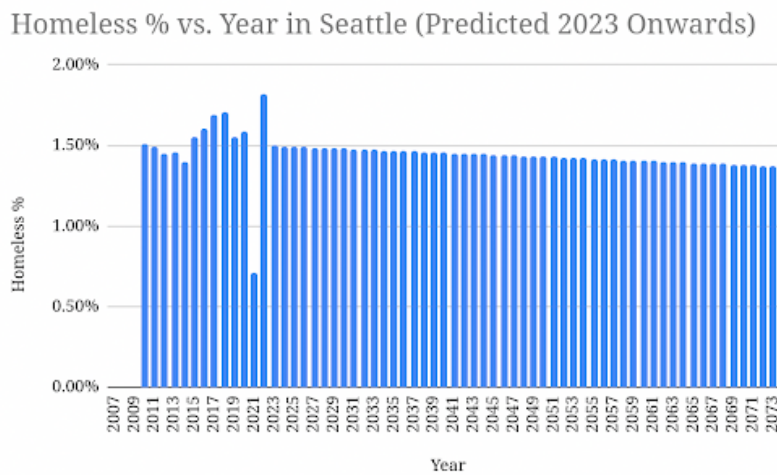


Figure 5: Percentage of the Population that is Homeless in Seattle, Washington

Therefore, for Seattle, let $S_T(x)$ be total number of homeless people in Seattle, where x is the current year (which is absolute from 0, such as 2024).

$$S_T(x) = 341.625x + 7902$$

Additionally, let $S_{\%}(x)$ be the percentage of Seattle's population that is homeless, where x is the current year (which is absolute from 0, such as 2024).

$$S_{\%}(x) = 0.65 - 2.473(x) \times 10^{-5}$$

3.4 Results

With this model, we can predict the following homelessness statistics for 2034 (10 years in the future), 2044 (20 years in the future), and 2074 (50 years in the future):

3.4.1 Albuquerque, New Mexico

Year	Years from 2024	Homeless Percentage	Total Homeless	Change from 2024
2024	0	2.304×10^{-3}	1,304.74	0
2034	10	1.914×10^{-3}	1,149.34	-155.4
2044	20	1.524×10^{-3}	993.94	-155.4
2074	50	3.54×10^{-3}	527.74	-155.4

3.4.2 Seattle, Washington

Year	Years from 2024	Homeless Percentage	Total Homeless	Change from 2024
2024	0	0.6	699,351	0
2034	10	0.6	702,767.25	3,416.25
2044	20	0.6	706,183.5	3,416.5
2074	50	0.599	716,432.25	10,249

3.5 Reflecting on the Model

Reflecting on the Models: Our homeless models for both the city of Seattle and Albuquerque proves a little weak, as the homeless population rate won't have a linear decrease or increase following the year 2023, but will have its ups and

downs. Although our data for the graphs are not perfect, it offers a distinct trend between the two cities, since Seattle's estimated homeless population rate is going up, while Albuquerque's homeless population rate is going down. This gives insight on the effectiveness of Albuquerque's methods in solving the homeless crisis, and should be explored furthermore.

4 Rising from this Abyss

4.1 Restatement of the Problem

4.2 Assumptions and Justifications

4.3 Model Development

4.4 Results

4.5 Reflecting on the Model

References

- [1] Chris Arnold, Robert Benincasa, Jacqueline GaNun, and Haidee Chu. There's a massive housing shortage across the u.s. here's how bad it is where you live. *NPR Economy*, 14 July 2022. Accessed on 3 March 2024 <https://www.npr.org/2022/07/14/1109345201/theres-a-massive-housing-shortage-across-the-u-s-heres-how-bad-it-is>.
- [2] U.S. Census Bureau. Selected housing characteristics. U.S. Census Bureau. Accessed on 3 March 2024. <https://data.census.gov/table/ACSDP1Y2010.DP04?q=albquerque%20city%20DP04&g=160XX00US5363000>.
- [3] U.S. Census Bureau. Selected housing characteristics. U.S. Census Bureau. Accessed on 3 March 2024. https://data.census.gov/table/ACSDP5Y2010.DP04?q=seattle%20city%20DP04&g=160XX00US5363000&hidePreview=false&vintage=2018&layer=VT_2018_160_00_PY_D1&cid=DP04_0001E&tid=ACSDP5Y2018.DP04.